RFID Networking Safety Systems

Through Java Network Programming

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1. Introduction

RFID is a powerful and relatively simple technology. Short for “Radio Frequency Identification”, RFID has a place in almost any walk of life. It can be used to improve productivity at work, safety and security in government, and quality of life at home.
Radio Frequency Identification Transponders or “tags” have been used in various forms for many years. Airplanes have been using radio transponders to signal and identify themselves to air traffic control radar on the ground since World War II. They are useful for identifying our pet dogs and cats, charge gasoline purchases, embedded chips in our vehicles ignition keys to prevent theft, library book checkout, and SunPass transponders (figures 1.0 and 1.1) used at toll plazas for paying road fees.

1.1 RFID System Outline

The basics of RFID are pretty simple. There are three actual components that are required to have a RFID system:

- Transponder or tag

- Reader or scanner or Antenna

- Controller

1.1.1 RFID Tags

On the surface it would seem like a tag sends a signal to the reader which is in turn registered by the controller, however this is not always the case. RFID devices can detect simple radio frequency (RF) transceivers, known as “tags”, which have unique information associated with them. Anywhere within their scan range, RFID readers can detect, differentiate, and log dozens even hundreds of tags in a matter of seconds. RFID tags are no commonly found at many large businesses where inventory tracking and safety is important. UPS uses RFID technology to track packages throughout the country, automatically updating a database that is accessible to clients! Car Max uses RFID tags not only to track employees, but also their car locations, test driving stats, and which salesman took the most test drives [1]. In more direct impact, several

European grocery stores have for the most part eliminated barcodes, opting instead for one reader to quickly scan all the contents of a shopping cart.

1.1.1.1 Passive

The reader or scanner actually sends out RF waves out from an antenna and waits for something to come into its range. It is important to know that they carry no power supply or controlling mechanism. When a tag comes within the range of a reader, it will pick up the RF wave and if it is within the right frequency range then it will send back a message in RF with its unique information, this is called reflected power. The RF sent from the reader actually powers the whole exchange of data between the reader and the tag. Passive RFID tags consist of at least two parts : an integrated circuit that serves to modulate and demodulate RF frequencies and an antenna in the form of coiled metal to increase data validity range and transmit and receive data.

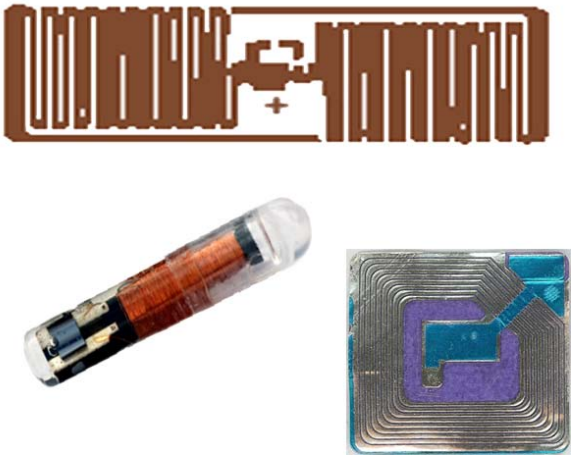


Figure 1.0 Examples of Passive RFID

1.1.1.2 Active

Since the project does not use any of these sorts of tags, they are only broadly covered. The tag itself has an internal power source which it uses to propagate the RF signal. Depending of the kind of power source, active tags may be read from a much greater distance than their passive counterparts. Active RFID tags are used in many commercial applications already. Many

government vehicles are “tagged” for tracking as well as personnel control. Figure 1.1 shows several examples of active RFID tags.

Figure 1.1 Examples of Active RFID

1.1.1.3 Battery Assisted Passive

Hybrid of both passive and active RFID technologies. Battery Assisted Passive tags use batteries to begin the RF data transfer once the correct frequency is detected.

1.1.2 Controllers

The master of the whole system is the RFID controller box. The typical RFID tag detection system is designed much like a RFID tag itself. It consists of a controller concerned with modulation and demodulation of the RF signal. The controller box specifies the frequency, acceptable tag signatures, and sorting algorithm to be used. This entire interchange of data can happen between 300 tags, 1 reader, and 1 controller within 5 seconds.

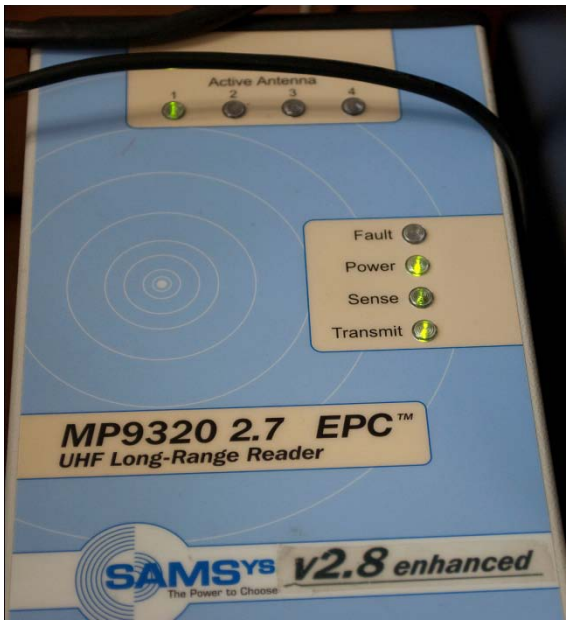


Figure 1.2 SAMSys RFID Controller

Figure 1.3 SAMSys Connection Interface

The SAMsys MP9320 v2.8e that is being used for this system is equipped with a serial port, a digital I/O port, and Ethernet port as seen in figure 1.3. These ports enable the controller box to be connected to a network several ways. Figure 1.4 show a possible connection schematic. This this example, the computer controller hosting the software would also need to be connected to the hub or server. Each controller box has its own IP address which is used by the software for differentiation and tag tracking.

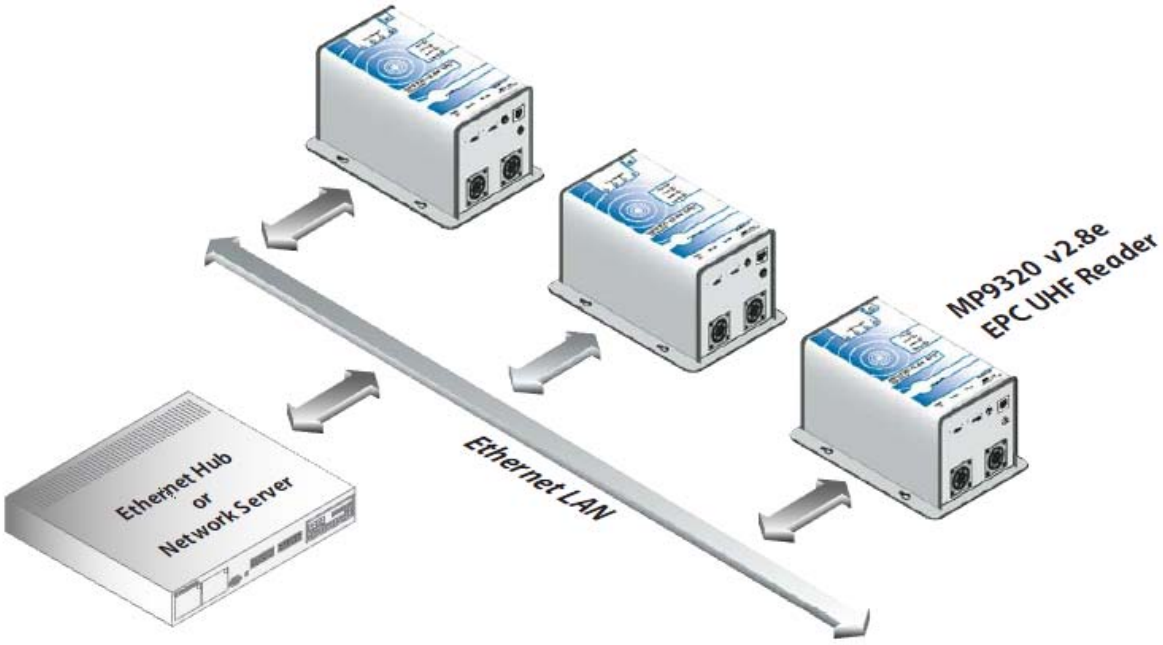


Figure 1.4 Controller Network [2]

The controller connects to the antennas through the 'Active Antennas' connections on the front of the box in figure (below). At least one antenna must be connected for any kind of RF signal to be sent or received. These connections are constantly being monitored by the controller and require special caps to be in place of the wires when an antenna is not connected. These caps will make the controller believe that there is an antenna present but is not receiving signal, thereby allowing the system to be functional. The controller's ultimate purpose is to identify and differentiate tags using different algorithms or scan settings. These indentified tags can be used for any number of purposes, however, the controller itself cannot differentiate between signals received from different antennas. For example, if a tag named 'tag 1' was presented to both antennas in figure 1.5, the controller would simply log it twice, not as two separate scans from different antennas.

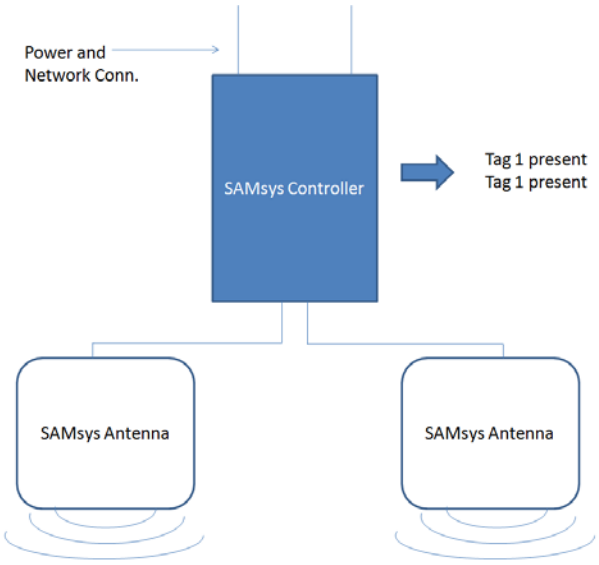


Figure 1.5 SAMSys Tag recognition

This means that if a system requires two separate registries to be made with tags (entrance and exit through different doors), then multiple controllers and multiple antennas will be required.

Important Notes: it is important to have the antenna caps in place when a cable is not attached or the system will not work. It is also important to mention that it is possible to set the controller's configuration to multiple antennas when there is only 1 antenna plugged in as long as the caps are in place [3].

1.1.2.1 SAMSys Software

The SAMSys Software provided with the MP3920 v2.8e system allows for control of all of the Controller box's features. Moreover, it allows the user to "halt" tags (render them unreadable for a chosen period of time), "kill" tags (stop reading), recognize new tags, and even create new information for tags. The software also allows the reader to be configured, changing its name or IP address as necessary.

The software is most useful for initial hardware set up, since it may be used to choose the number of operational antennas and sending commands for operation the controller. However, the most common use of the SAMSys software is simple tag reading, differentiation, and time stamping. Figure 1.6 illustrates these functions.

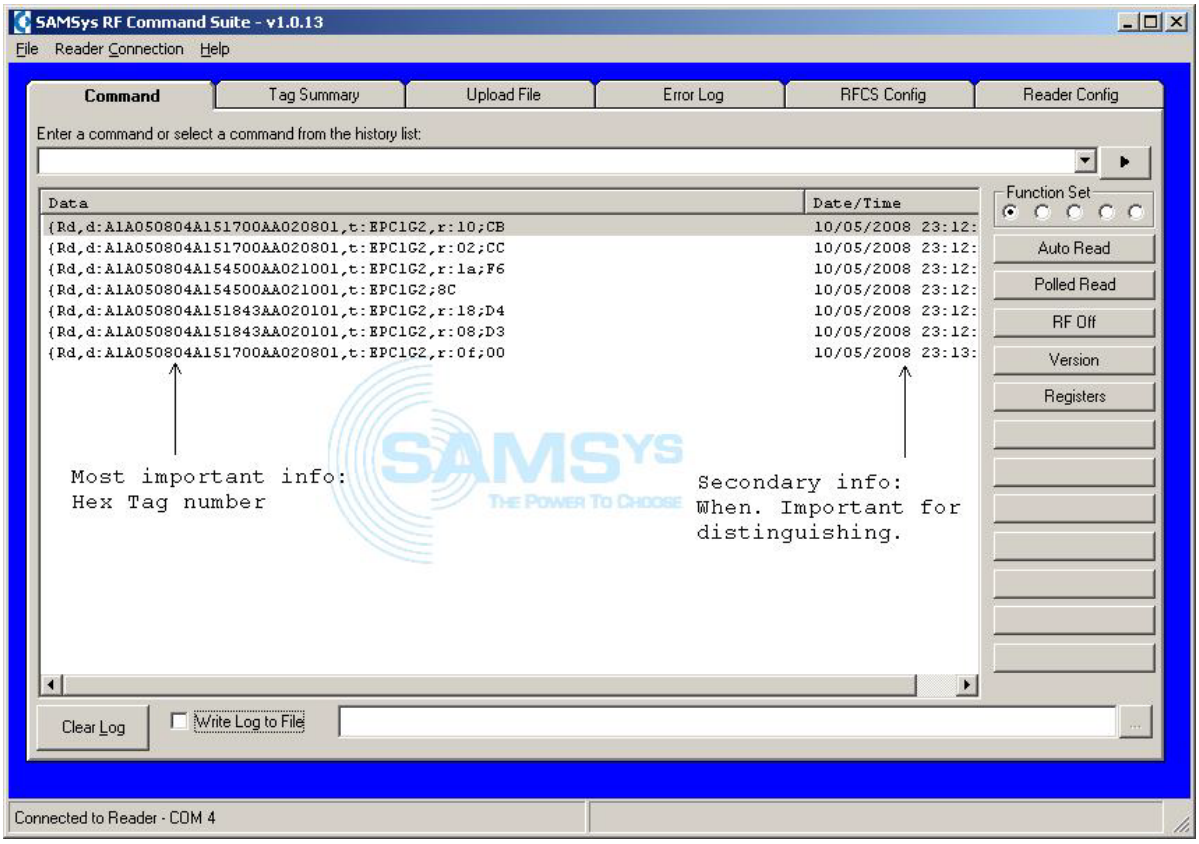


Figure 1.6 SAMSys Screenshot [3].

1.1.3 Readers/Antennas

In order for a tag to be picked up, the controller has to emit an RF signal through one of its antennas. The RF sent from the reader actually powers the whole exchange of data between the reader and the tag. However the reader does not know if it should be looking for a specific kind of tag or for that matter how far it could be, the reader only emits and receives the RF signal.

Figure 1.7 SAMSys Reader Antenna with tag

Figure 1.8 Antenna end of reader

Each antenna is connected directly into the controller through a coaxial cable.
The total gain, or total intensity of an antenna in a certain direction, of the transmission system is the gain of the antenna minus the loss of the cabling. For example, if the antenna has 4 dB of gain and the coax cable has 2 db of loss over its length, the total gain is 2 dB. This characteristic of the antenna cable limits the distance that the controller can be from the antennas.

1.3 Where the Last Project Left Off

RFID has been an ongoing data acquisition (DAQ) project at FGCU since early 2008 [4]. As far a programming goes, a relatively complex RFID java server/client application has already been written, but it lacks a developed internet implementation and for that matter, a network structure[3]. Moreover, half of the code is missing rendering the project in its current state unusable. This means that this project will need to use minimal carry over from the previous project. However, in the last project report several options for improved work productivity were discussed, one of which is discussed in the next section.

2. Problem Description

2.1 Problem and Primary Objective

A particular experiment was explained in "Applied RFID Technology" where employees would have RFID tags on their cellular phones which could be used for employee tracking, productivity monitoring, and sensitive information security [3]. The report proposes placing readers at strategically important locations and monitoring them from a master computer. This system could be used to offer access to areas through the cell phone and allow the company to have increased security of sensitive material. Even if a subject is able to make it through the security door by walking in with someone authorized, it would be possible to detect their presence and realize that they do not have access by constantly pinging for tags. Thus if the number of authorized tags identified is less than the number of people detected, than security would be alerted. This leads the inspiration of the proposed project. On July 23, 2009, a six car metro train on Washington DC's redline slammed into a stationary train resulting in nine deaths and up to 100 injuries. This accident occurred because there was no systematic verification of trains between stations and the only trafficking system consists of signals and rail changes.

The primary objective of this project is to ensure safe train traffic through RFID tag/reader implementation. This project will concentrate on the hardware configuration necessary to make this system possible and the software that will monitor the tags.

Hardware requirements:

1. Reader shall "pick up" different tags
2. Reader shall send tag information to controller
3. Controller shall use multiple readers
4. Controller shall network with computer controller
5. Computer controller shall host software and controller settings

Software requirements :

1. Software shall differentiate many kinds of tags
2. Software shall connect to controller independently
3. Software shall store date/time that tags were scanned

4. Software shall notify user of unsafe state
5. Software shall be Real Time safety critical system safe

2.2 Hardware Problem

As previously described, the SAMSYS MP9320 2.8e, or controller, is capable of being accessed by RS-232 serial, RS-485, and Ethernet connections[2]. While the RS-232 appears to be working correctly, any attempts to connect to the controller using its Ethernet port have not been successful[5].

2.2.1 Set up

The controller's user's manual calls for all connections to be established prior to starting the SAMSys software. Once this has been done, the software should automatically detect the controller in either Serial or Ethernet connectivity. Continuing, if the controller is not automatically detected, then it may be manually detected using an executable included in the software disk called digidscvr.exe. This tool is titled Digi Device Discovery Tool and should find any compatible device connected to the network.

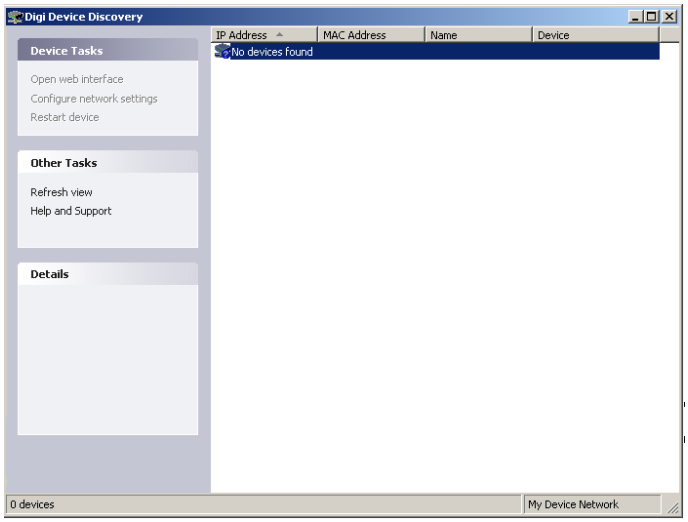


Figure 2.0 Digi Device Discovery Screenshot

Figure 2.0 shows that no devices were found on the network. Several networks were set up including WAN, LAN and direct connection as well as several versions of Digi Device Discovery were utilized but all reach the same result.

2.2.2 Troubleshooting

All attempts to contact SAMSys were unsuccessful since at the time of this report the company no longer exists. The only troubleshooting information specific to the MP9320 2.8e available at this time is a diagram from the user's manual (figure 2.1)[2].

No Ethernet connectivity	External Ethernet cable faulty.	Check cable and replace if necessary.
	Wrong jumper setting.	Ensure RS-485/Ethernet Jumper J4 is across Pins 2-3.
	Wrong Ethernet IP address.	Use the Digi Device Discovery application to reverify IP address.
	Reader board failure.	Replace reader.

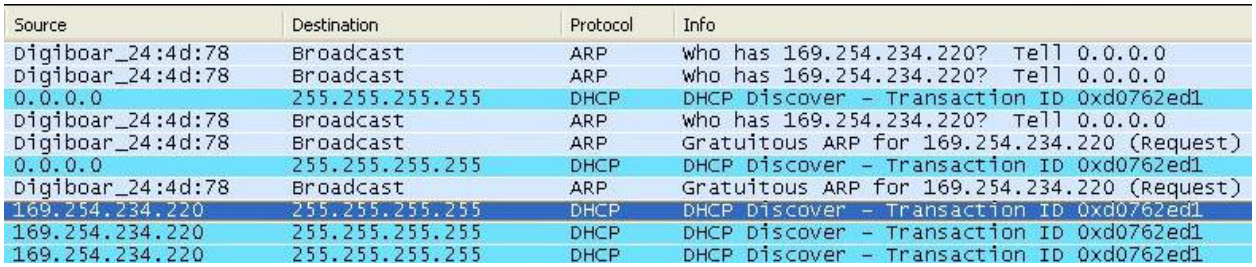
Figure 2.1 SAMSys Controller Troubleshooter[2]

"The MP9320 is equipped with an optional TCP/IP Ethernet port and embedded IP device server. This reader is configured for automatic IP address allocation using the Dynamic Host Configuration Protocol (DHCP) Mode and the reader automatically extracts the IP address from the DHCP server. This is the default mode for the reader as it is shipped from the factory"[2] .

As stated above, the controller should automatically ask for an IP address allocation using DHCP. Since it is apparent that there is no IP address, more information on how this process works is needed.

Dynamic Host Configuration Protocol (DHCP), allows a TCP/IP client to automatically request and receive an IP address from the issuing server. When a device connects to a network, a flood of traffic is generated to see the available hosts, as well as available servers and services.

Typically, a device will only respond if there is a request directly to that device, or if a broadcast call packet is sent over the network. This 'broadcasting' requests that every device that receives it should respond to the device that sent the packet. Knowing this, it is possible to use a broadcast packet to track every device on the LAN "By placing network card in 'promiscuous' mode, along with a packet capture driver, it is possible to capture all network traffic passing by that network card host"[5]. From here, software called WireShark may be used to monitor results and see exactly what devices are connected and under what protocol (figure 2.2). This process consists of receiving and filtering all results that come into the network card by a process of elimination.



Source	Destination	Protocol	Info
Digiboar_24:4d:78	Broadcast	ARP	Who has 169.254.234.220? Tell 0.0.0.0
Digiboar_24:4d:78	Broadcast	ARP	Who has 169.254.234.220? Tell 0.0.0.0
0.0.0.0	255.255.255.255	DHCP	DHCP Discover - Transaction ID 0xd0762ed1
Digiboar_24:4d:78	Broadcast	ARP	Who has 169.254.234.220? Tell 0.0.0.0
Digiboar_24:4d:78	Broadcast	ARP	Gratuitous ARP for 169.254.234.220 (Request)
0.0.0.0	255.255.255.255	DHCP	DHCP Discover - Transaction ID 0xd0762ed1
Digiboar_24:4d:78	Broadcast	ARP	Gratuitous ARP for 169.254.234.220 (Request)
169.254.234.220	255.255.255.255	DHCP	DHCP Discover - Transaction ID 0xd0762ed1
169.254.234.220	255.255.255.255	DHCP	DHCP Discover - Transaction ID 0xd0762ed1
169.254.234.220	255.255.255.255	DHCP	DHCP Discover - Transaction ID 0xd0762ed1

Figure 2.2 WireShark monitoring network traffic

2.3 Software Problem

The software requirements as outlined in section 2.1 must be satisfied by the software in three phases:

1. Establishing communication
2. Control System
3. Data Storage

2.3.1 Establishing Communication

Software shall connect to controller independently. The software must be able to understand the reader and successfully receive data. In order to establish communication, the right protocol must be used by the software and the controller's settings must be properly used.

2.3.2 Control System

Software shall notify user of unsafe state. When the software scans a tag that puts the system into an unsafe state, it should alert the user that there is a problem. This can be done through a constant check for unsafe state as a condition for an unsafe state protocol. Moreover, the user should be able to search for users that are registered in the system and see their pertinent information (last scan, how many scans).

2.3.3 Data Storage

Software shall store date/time that tags were scanned. A storage system for data retrieval must also be implemented to enables information searching. However, most importantly, data storage

ensures a safe state between software rebooting (since the actual data is not stored in the software) and with long intervals between scans.

The rests of the software implementation depends in how to network from multiple controller boxes to a single master computer, hosting the stored information and user. Lastly, the software language chosen for this safety system must be certified real time system safe. Software concerned with real time systems are those that "…operate under strict timing requirements and may cause significant damage or loss of life, if not operating properly"[6].

3. Solution

If in the Washington Metro system there had been a constant validity verification or an automated safe state system, rather than the dated traffic signal system, then this fatal crash could have been avoided. I propose that it is possible to improve safety and traffic flow in a metro rail system through an RFID database with crosschecking and a master/slave relationship. In this proposed solution, each individual train would carry RFID tags and internal controllers. As the trains passed in and out of tunnels or high traffic areas, readers pick up on which trains is where. If for whatever reason a train enters a tunnel but does not leave it, all traffic to the tunnel stops via the train's internal controller. Similarly, if the trains are mapped using RFID with checkpoints, it becomes easy to see where major chokepoints are and how they can be alleviated.

The software solution proposed is titled "Java RFID Serial Safety Software" hereafter referred to as JRSSS is based on the layers set out by the SAMSys software available with the SAMSys MP9320 v2.8e as seen in figure x.x in section 3.2. JRSSS implements the following layers as classes :

1. Mapping Layer - implemented as GUI class that controls all I/O and commands.
2. Data Management Layer – implemented as the Databasewriter class which controls tags and manages tag properties as well as data storage
3. Connection Management Layer – implemented as Serial class that manages all computer to device traffic.

3.1 Software Language

The choice to go with Java for software language comes after a study of which languages are effective for a real time safety system implementation. While this project only covers a basic implementation, the availability for a continuation lends to choosing a "safe" language. Java currently has a real time specification RTSJ and is also currently developing a safety critical Java system called SCJ which would deal with several safety issues inherent in java like garbage collection and multithreading (Kornecki & Zalewski, 2009). Real time specification for Java (RTSJ) is a combination of technologies that currently allows programmers to write programs that meet many of the demands of real time systems in the Java programming language. The

existence of this technology makes Java a suitable language over C/C++ for this safety application.

3.2 Establishing Communication

3.2.1 Serial vs Ethernet

Due to the present hardware problems not permitting Ethernet communication from another device, serial communication is the next logical step. This serial implementation is based on the Simple Serial Interface (SSI) which is a free developer tool available online. Simple serial means that the program sends/receives bytes and controls the state of serial communication signals in the simplest way possible. As simplicity is the main goal in this class, the assumption must also be made that there is no hardware or software flow control and that communication signals can freely be controlled. Flow control suggests that there is a stop or pause in transmission , either write or read from either computer or device, to allow the full transmission to be sent. This may mean that due to excessive commands, tag reads, or 'noise' the device stack may overflow and cause a failure. Due to the level of implementation which this project is accomplishing, this risk is not addressed in this document.

Table 3.0 Serial Settings In Use: MP9320 v2.8e

RF Scanning	Continuous
Serial Reporting	Continuous
Baud Rate	57600
Data Bits	8
Stop Bits	1
Parity	None
Flow Control	None

The Serial class that handles connections completely replaces the TCP/IP class and Discovery class, rather than supplements, which is found in figure 3.0. The Connection Management Layer functions in the SAMSys software by communicating with the physical transport layer of the

reader. This layer is based on the IConnection interface ideally supports Serial and TCP/IP connectivity.

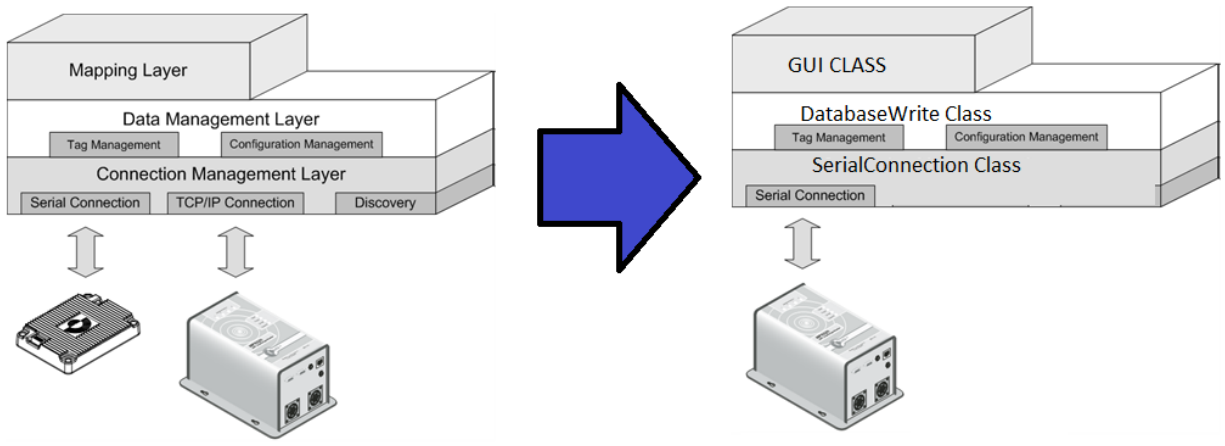


Figure 3.0 SAMSys Management Layers (left) to Software Development Classes (right)

The serial connection detects the com port to which the device is connected and automatically establishes a connection. This connection is held by the system until it is released by the user (by closing the program) or until it times out (from possible hardware/device fault).

Java Serial connection code snippet for typical serial connection:

```
        // New instance of the serial port.
    if (m_IsNative) {
        m_SerialPort = new SimpleSerialNative(m_PortIndex);
    }

        // New a serial port.  Pass in comm port number
SimpleSerialNative(int comPort) {
        _initPort( convertToCommString(comPort), 57600, 8, ONESTOPBIT,
        NOPARITY);
      }
```

```
find_open_serial_port:
          for (ii = 0; ii < m_PortMenuItem.length; ii++) {
          try {
              m_PortIndex = ii + 1; // the serial port wanted
              initSerialPort();  // Try opening this serial port.
            System.out.println("Opening serial port Comm" +
            m_PortIndex);
          break find_open_serial_port;
```

3.2.2 How does JRSSS Serial Work

Serial connections work by transmitting data 1 bit at a time over a physical cable, in this implementation a RS-232 cable but can be different. The data is many times stored in byte arrays which can hold whole strings and transmitted again 1 bit at a time, only this time the byte array is taken as a whole unit instead of separate bits. This helps process of passing command strings rather than single chars. JRSSS works by calling serial class which converts any command or I/O to or from the device from bits to strings or string to bits. It is also important to note that the Serial class communicates exclusively with the device. Any command passing or reading needs to be passed from its respective class to the Serial class for transmission to or from the device. Figure 3.1 shows the detection of the serial device in a similar detection program as used to look for the IP address of the device.

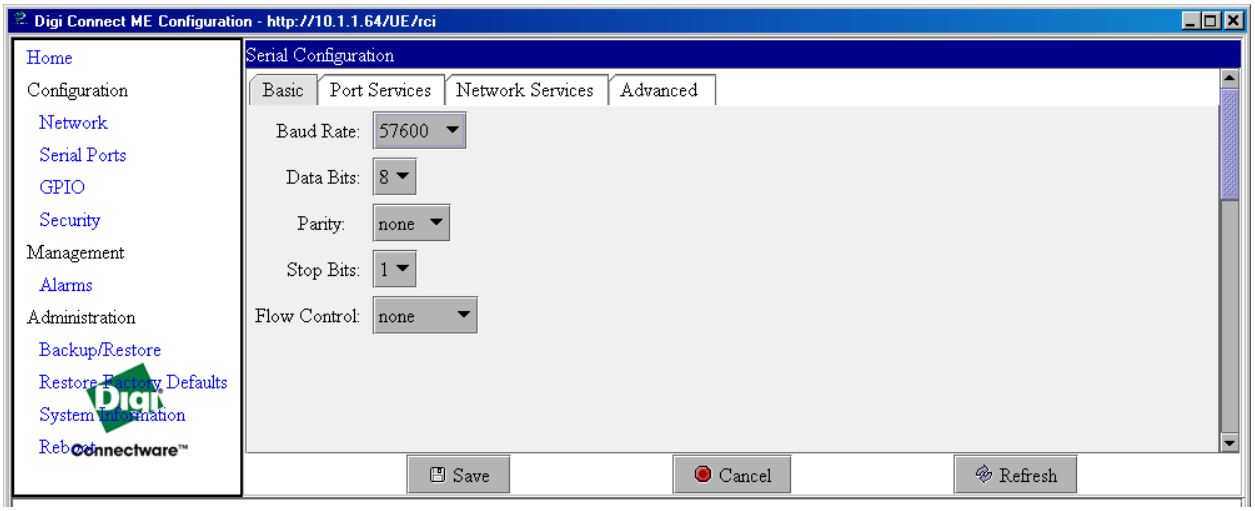


Figure 3.1 Successful Discovery of Controller Through Serial Connection

Physical transmission of bits also means that aside from noise, the issue of distance exists. The further away that a device is from its pair means that it will need a longer RS-232 cable.

Unfortunately, serial communications are greatly limited by this distance and quickly lose discernable data. It is possible to amplify the range of discernable serial communication, but it requires an amplification which again, only extends the length of the cable but does not solve the problem[2].

3.3 Control System

The user is must be notified of any unsafe state. But this may change from application to application because an unsafe state in one may be acceptable in another. For example, in a social networking website, it may be acceptable to have some data loss to maintain the speed of database access and since old data is rarely retrieved, a marginal loss is acceptable. In contrast, hospital records stored in a database must not be lost and extra care must be taken to maintain a lossless state. In this way, an unsafe state alarm must reflect the application that it is serving.

3.3.1 Application

In the proposed train traffic example, the application would be a notification that there is a potentially unsafe state in some tunnel, track, or intersection. This alert could be generated by a constant cross check of tag scans and database records. As a train passes through an intersection, enters a track, or enters a tunnel, its tag would be scanned and a time stamp would be issued. Figure 3.2 illustrates the example as follows:

The 23 train heading north bound from point X to point Y must pass through an intersection where an eastbound train joins the north redline track. If a the 23 train passes checkpoint A and has its tags scanned/registered but has not yet been scanned by the B checkpoint antenna, then a train leaving station C eastbound would have an unsafe state and be forced to stop operation. Moreover, if the 23 train takes longer than usual to reach checkpoint B or never reaches it at all, then train 23 will be in an unsafe state.

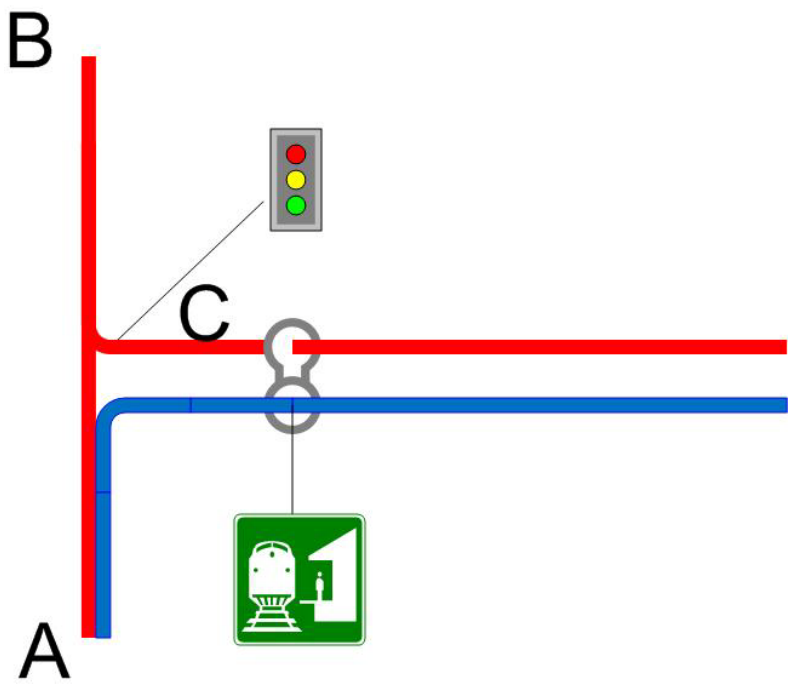


Figure 3.2 Unsafe State Train Example

3.3.2 GUI

The GUI acts as a user notification system where if there is an unsafe state, the user is alerted by the software. Final implementation should include individual controllers within trains to be alerted of the unsafe state and discontinue operation until the flag is reset or an administrator overrides the unsafe state.

3.4 Data Storage

In order to maintain safety and program independence, the data is stored outside of the software, meaning that a software fail state does not mean data corruption. The data storage occurs in a database which networks to the actual java program.

3.4.1 Database

The chosen database is the 2007 Microsoft Access database due to its ease of use and readily editable query features. Access is like many basic databases in that it involves tables,

forms, and queries, but unlike other more complex database platforms it does not require complex permissions.

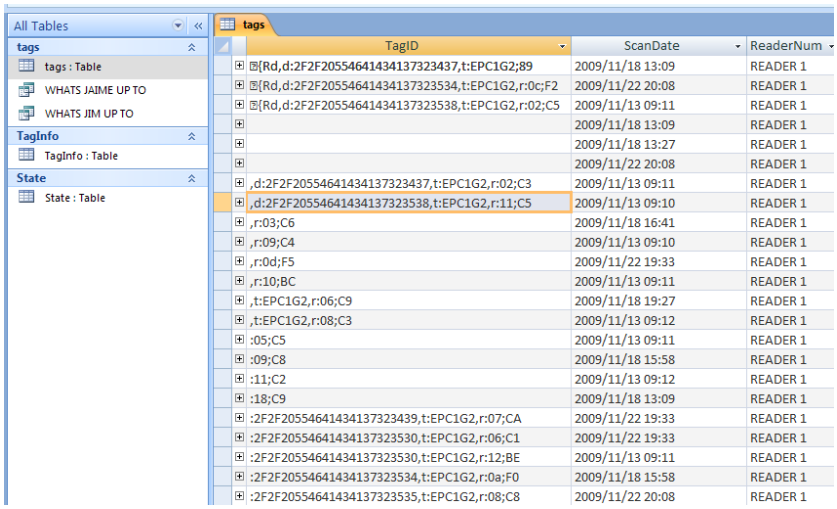


Figure 3.3 Access Data Base holding RFID Information

3.4.2 JDBC Connection

To connect to any external database from a Java program, a Java DataBase Connection (JDBC) needs to be made. To establish a connection two steps are necessary :

1. Import the database driver
2. Create a JDBC connection

While for many systems it may be necessary to download a separate database driver (ex. SQL 2008 or Oracle 11g), for the Access to Java connection in this project it is unnecessary. Rather, I use the ODBC service available through Windows and the SQL drivers already available in Java. The java api reserved for database operations can be accessed by importing the following line: "import java.sql.*;" and will allow the programmer to access classes such as Connection, Statement, and ResultSet [7].

The ODBC Data Source Administrator in figure 3.4 can be accessed in the administrative tools menu of most Windows operating systems.

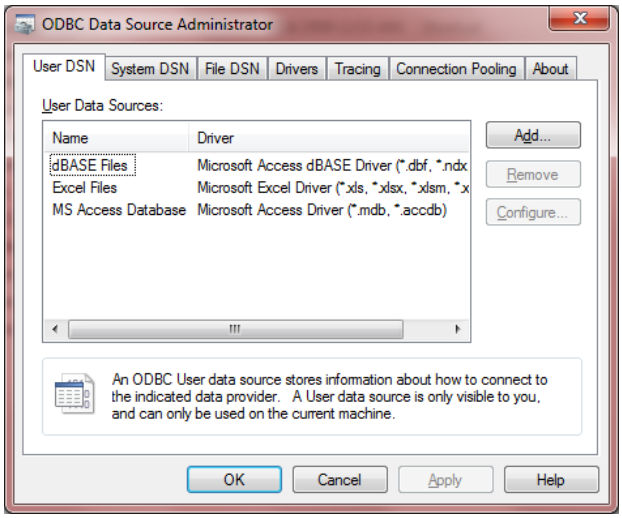


Figure 3.4 ODBC setup window

Java Method for creating a connection from Java to the ODBC created above:

```
 // Method to make the connection to database and perform its setup
   void OpenConnection () throws SQLException {
            // Make the connection to ODBC title rfidsource
            conn = DriverManager.getConnection("jdbc:odbc:rfidsource");
            Statement s = conn.createStatement()
      }
```

Java Method for writing data into database

```
   void WriteData(String tag, String time, String Reader) throws
SQLException{
      Statement s = conn.createStatement();
      String state = "INSERT INTO tags VALUES('" + tag + "', '" + time + "',
      '" + Reader + "')";
      int temp = s.executeUpdate(state);
   }
```

3.4.3 Data Types and Delimiters

Half of the data that is inserted into the database comes from the serial class after decoding. This class, as explained in section 3.2.2 transmits and receives bits of information. When the bits are received, they are converted to text or “Strings” in the Java language. This data is then passed into the database. However, in order to successfully receive any data from an ODBC or JDBC connection, the field’s data type and the data type of the data being received must match. In Access, the data type for text is “Text”.

The following is a typical tag information transmission:

{Rd,d:E016000000000D53,t:IS186A;C4

What makes this information significant is that every piece of information is a mixture of letters and numbers. The actual tag identification is found between the first and second commas. It is easy to see that it is impossible to use any of this information as a typical integer primary key as used in normal databases. However, since every tag has a different unique identifier, it is possible to use this value as its indexed name.

The receipt of a tag is usually followed by its time stamp. This data follows the tag identifier above and is separated by a semicolon. It is possible to delimiter or separate this information based on this punctuation. After the java program sends a string with the complete information (identifier and timestamp) the database automatically separates the information into TagID and DateTime. Other information passed to the database include the tagName and ReaderNo which is the signature of whichever controller registered the tag event. It stands to reason that all data types in the Access database must be of Text type such as in figure 3.5 in order to receive and send data successfully.

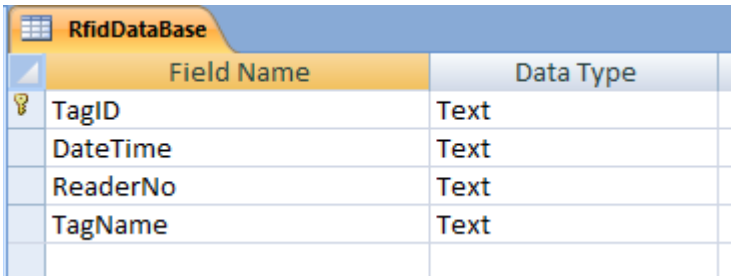


Figure 3.5 RfidDataBase Table Design View

Lastly, the noise from the serial connection creates substantial “garbage” data that is also inputted into the database. The java program can take care of this by using the most common form of a tag and use that as the accepted TagID.

3.4.4 Queries

In order to receive data from a database it is possible to query the data or selectively search the data. Queries are pieces of code that can be used to return data that fits certain criteria from selected tables, rows, and columns. Queries are executed within the database and make

databases, or at least the results, programmable. This code varies from one database to another and must be specifically written for a database in order to function properly. The following statement is a functioning query that will return all tags starting with the most recently added data to RfidDataBase.

```
SELECT TagID, DateTime

FROM RfidDataBase

ORDER BY DateTime DESC
```

In plain English, this simple query SELECTS the column TagID and DateTime FROM the table RfidDataBase and ORDERs the data BY the DateTime value in DESCending order. The issues arise when this statement has to be passed into the database from an outside source for execution. This is where JDBC statements come in. JDBC allows a statement to be created from the Connection. This statement can be used to execute a query, update data and return a set of results. Typically, a JDBC statement is used to pass some request into a database or send data, but a query is intended to return data. Therefore a JDBC ResultSet is necessary to receive the queried information. Assuming that a connection named “con” has already been established, the following is a JDBC statement equivalent to the previous in this section:

```
Statement stmt = con.createStatement();
ResultSet results = stmt.executeQuery(
"SELECT TagID, DateTime FROM RfidDataBase ORDER BY DateTime DESC");
```

It is also possible to concatenate variables into the statement as in the following example:

```
ResultSet results = stmt.executeQuery(
"SELECT TagID, DateTime FROM RfidDataBase WHERE TagID =” + Var + “ORDER BY
DateTime DESC");
```

This code would return the most recent TagID and DateTime for a specific tag value in var. In this fashion, queries can be used to return any value from the database as needed by the java program.

3.5 Commands

Sending commands to the reader follows different guidelines than sending commands to the database. These commands deal entirely with the connection and the ability to send entire string blocks through byte arrays to the controller.

3.5.1 CHUMP

The MP9320 v2.8e is equipped with a data layer that can receive commands and perform tasks. The Comprehensive Heuristic Uniform Messaging Protocol (CHUMP) provides an interface to the controllers data layer and can be expressed as strings.

When a command needs to be sent to the reader a “CHUMP Tag” needs to be generated.

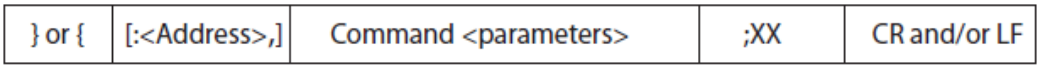


Figure 3.6 Command Syntax of CHUMP Tag

Each CHUMP tag command begins with a ‘ } ‘ which signifies that the following code is a command. The Address is the space where the tag id and write address within the tag is stored. The command is what is actually to be done. XX is the checksum and CR is the end of line check[2].

CHUMP Tags can command the controller to:

1. Read data from tag
2. Write data to tag
3. Halt/Quiet a tag
4. Read the onboard I/O ports

With this information it is easy to see how one could send a message to the controller that names a tag. The following code line uses the write function of CHUMP to write the string “BOB” into the tag with the id of “E00300001122334455667788”:

}d:E00300001122334455667788,wt b:BOB,a:20,CR!

4. Experiments

The properly test the validity of the project and ensure its success as a safety system, a proper experiment should be designed. This experiment must take into account the software requirements and one by one test their success or failure. Also, since this is a test of the software, the experiment must ensure, or assume if ensuring is impossible, that the hardware requirements are satisfied. At this stage in implementation, the software is by no means fully developed. Furthermore, only one controller unit is available for use barring the possibility of any location oriented experiment. Therefore, rather than testing the complex and safety-critical train example, the experiment will focus on another less critical real life example.

4.1 Experiment Scenario

In a large warehouse, it has become difficult to control the timesheets of employees. Several entrances, odd shifts, and lost punch cards have prevented workers from consistently providing accurate records of their work hours. Through RFID and JRSSS it is possible to track employee hours and prevent loss of wages or overpayment.

4.1.1 The Set Up

The front of the warehouse has a narrow entranceway through which much of management enters the building (figure 4.0). The back of the warehouse has a large gate that is open in the mornings and evenings to let employees and trucks in and out of the building (figure 4.1).

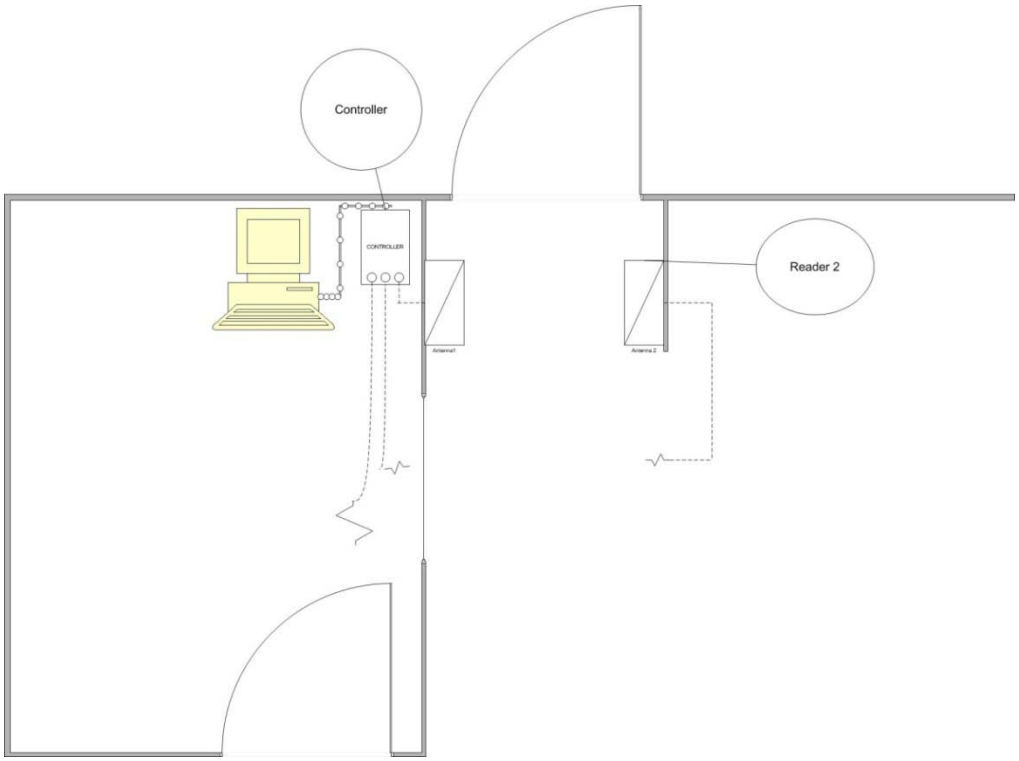


Figure 4.0 Front Entrance of Warehouse RFID Experiment

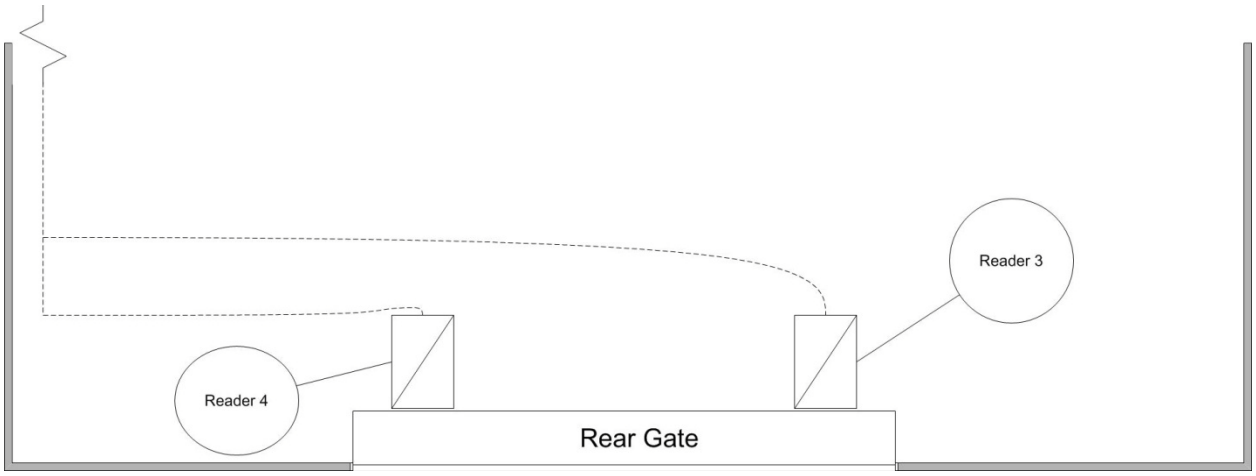


Figure 4.1 Rear Entrance of Warehouse Experiment

By giving each employee a badge that is equipped with passive RFID technology, it is possible to track employees log in and out hours down to the second for any given day. As employees walk in and out of the entrances, their tags are picked up by the readers and sent to the controller which then conveys the data to the JRSSS. The software passes this data into the database for

storage and can query the information needed. At the end of the day, the computer could automatically subtract the last register of an employee's tag by the first to find the exact hours present at the site.

4.2 Requirements Testing

4.2.1 Software shall differentiate many kinds of tags

As employees walk in and out of the warehouse's openings, they should be identified and registered as present within the database. To test this requirement, the JRSSS should already be operational. Presently, there are two activated tags within the system named 'Jaime' and 'Jim'. These two tags represent two employees walking in at the beginning of a work day. Bring one RFID tag within the range of a reader (it does not matter which one). Type the corresponding name into the search text box. The program returns the last scan date for that particular tag.

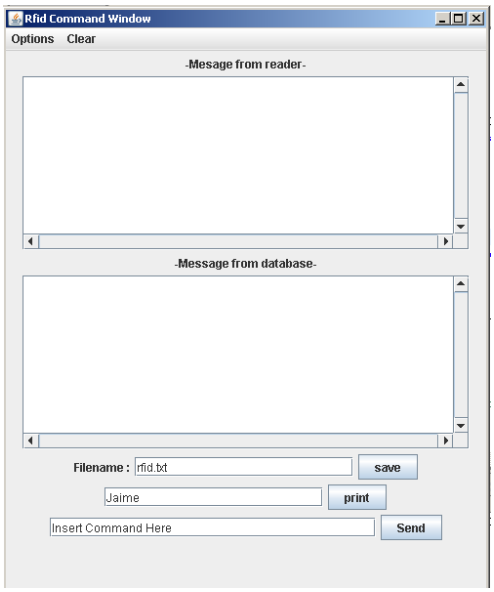


Figure 4.3 Graphical User Interface for JRSSS

Wait a few minutes and bring both within the scan range of a reader. Type the corresponding names into the search box, one at a time. The program returns the last scan date for both tags, even if they were scanned at the same time.

4.2.2 Software shall connect to controller independently

The JRSSS and MP9320 v2.8e are meant to be constantly operational. Therefore, connection and disconnection is not a common aspect of operation. However, it is obviously an important step that must occur prior to the first tags being successfully registered by the software (but controller may pick them up if it is on but not connected to computer).

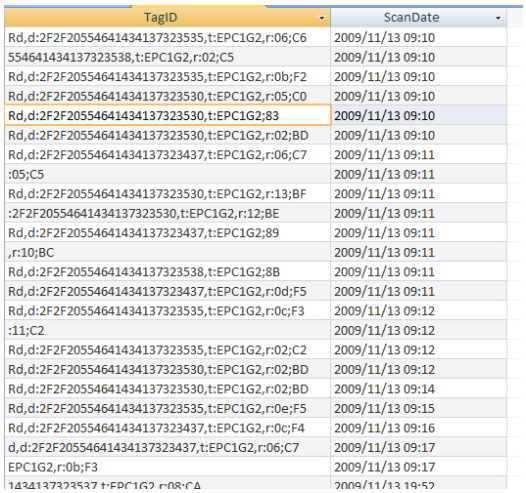
First, ensure that all connections are properly made. Power cord must be plugged into 120V outlet and into controller box. Antenna to be used must be connected to the front of the controller box and any unused ports must have the proper caps in place. Lastly, the RS-232 serial cable must be connected from the device to the computer's COM port (COM port 1 is preferable if there is more than one port but it is not necessary).

Start up the software and observe the System messages. "Connected to COM port 1" should be displayed if successful. If not, then "COM port cannot be found" may be displayed. Another check to ensure the connection's success is to scan a tag and see if there is any activity in the GUI. If so, then the connection has successfully been made.

4.2.3 Software shall store date/time that tags were scanned

Once a tag has already been scanned and registered, the tag's information may be requested by entering its name into the search box. However, if a specific instance of the tag is required or a specific date/time is needed, then it must be found in the database.

By opening the RfidDataBase, it is easy to see that each tag instance is followed by its scan date and time. To make sure this is accurate, simply scan a tag, making note of the tag name and time scanned. Then check the database or use a query to find the tag's most recent scan date.



TagID	ScanDate
Rd,d:2F2F20554641434137323535,t:EPC1G2,r:06;C6	2009/11/13 09:10
5546414341373235 38,t:EPC1G2,r:02;C5	2009/11/13 09:10
Rd,d:2F2F20554641434137323535,t:EPC1G2,r:0b;F2	2009/11/13 09:10
Rd,d:2F2F20554641434137323530,t:EPC1G2,r:05;C0	2009/11/13 09:10
Rd,d:2F2F20554641434137323530,t:EPC1G2;83	2009/11/13 09:10
Rd,d:2F2F20554641434137323530,t:EPC1G2,r:02;BD	2009/11/13 09:10
Rd,d:2F2F20554641434137323437,t:EPC1G2,r:06;C7	2009/11/13 09:11
:05;C5	2009/11/13 09:11
Rd,d:2F2F20554641434137323530,t:EPC1G2,r:13;BF	2009/11/13 09:11
:2F2F20554641434137323530,t:EPC1G2,r:12;BE	2009/11/13 09:11
Rd,d:2F2F20554641434137323437,t:EPC1G2;89	2009/11/13 09:11
,r:10;BC	2009/11/13 09:11
Rd,d:2F2F20554641434137323538,t:EPC1G2;8B	2009/11/13 09:11
Rd,d:2F2F20554641434137323437,t:EPC1G2,r:0d;F5	2009/11/13 09:11
Rd,d:2F2F20554641434137323535,t:EPC1G2,r:0c;F3	2009/11/13 09:12
:11;C2	2009/11/13 09:12
Rd,d:2F2F20554641434137323535,t:EPC1G2,r:02;C2	2009/11/13 09:12
Rd,d:2F2F20554641434137323530,t:EPC1G2,r:02;BD	2009/11/13 09:12
Rd,d:2F2F20554641434137323530,t:EPC1G2,r:02;BD	2009/11/13 09:14
Rd,d:2F2F20554641434137323535,t:EPC1G2,r:0e;F5	2009/11/13 09:15
Rd,d:2F2F20554641434137323437,t:EPC1G2,r:0c;F4	2009/11/13 09:16
d,d:2F2F20554641434137323437,t:EPC1G2,r:06;C7	2009/11/13 09:17
EPC1G2,r:0b;F3	2009/11/13 09:17
1434137323537,t:EPC1G2,r:08:CA	2009/11/13 19:52

Figure 4.4 Date and Time Stored in Database

4.2.4 Software shall notify user of unsafe state

This requirement takes on two roles. First, it means that if for some reason the software does not believe that operation is safe or possible, it should return an error or a message to stop operation. Since this is not a safety critical experiment, this safe state is not applicable. However, the equivalent for an unsafe state for this system would be if a new unrecognized tag were introduced or if an employee's tag information had not yet been entered when it was requested. The latter circumstance may be tested by entering a made up name into the search box. In this instance, since there are only 2 programmed name, it can be any string other than 'Jaime' or 'Jim'. It's noteworthy to say that these names are not case sensitive. An error message alerting the user that this person does not exist within the system will be displayed.

The second role that unsafe means for this application has to do with the waves emitted by the antennas. While not yet implemented, the final version of this safety software must alert users when there is a potential danger posed by the RF waves coming from the antennas. An employee with a pace maker or highly sensitive hearing aids may have his or her device damaged by strong RF waves. While the SAMSys disclaimer on the actual controller box in figure 4.5 claims to not have harmful effects, there have been cases of accidental injury related to RF signals. The controller box has varying signal frequency and wavelengths and may be changed fit the physical needs of certain employees.

Model MP9320
UHF Long-Range Reader
SAMSYS
THE POWER TO CHOOSE
This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.
FC
FCC ID: QRKH1469320
CANADA 210
IC: 4572A-MP9320
This product makes use of intermec US Patent 5,550,547 when operating in accordance with ANSI MH10.8.4 and AIAG B11 standards.

Figure 4.5 SAMSys MP9320 Safe Operation Disclaimer

5. Conclusion

This project is an investigation into an important area of software development. Safety-critical real time systems exist in most aspects of life; from the airport, to cars, and even in hospital equipment. These systems' functionality and safe operation depends on smooth operation and correct event handling, which comes directly from the programmer. It is the goal of any safety- critical real time system program to accurately, safely, and compactly encapsulate all aspects and scenarios of a situation in the software and properly handle them in such a way as to avoid damage to property or loss of life.

5.1 Summary

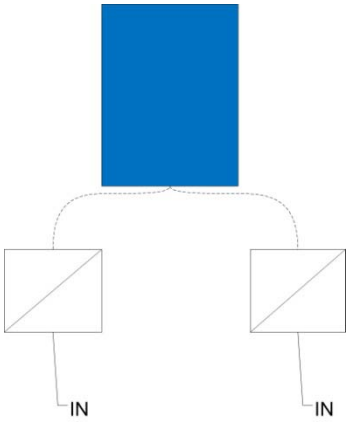
The Java Realtime Serial Safety Software (JRSSS) is the first step toward developing a complex and integrated safety monitoring system for a metro rail system. The steps and ground work set out by this document is intended to be a start to a larger, more broad project that could cover various professions/majors.

RFID is a growing technology that is trusted by some of the largest companies in the United States. The growth in popularity is not due to the technology' cost, which remains high, but because of the technology's potential. RFID is capable of accurately tracking high speed trains with the use of tags, it is capable of being used to track large inventories down to the last item. During WWII, a technology similar to RFID was used to safely identify fighter planes at runways. With steps in the right direction, it can also be used to ensure safe operation in more aspects of daily human life.

5.2 Project Status

As the project stands right now, it is being limited by the hardware implementation. Unfortunately, only one MP9320 v2.8e controller is available for use and is actual not functioning correctly. This eliminates the possibility of locational safety testing because the controller cannot differentiate between antennas when a tag is scanned. This means that the only functionality that one controller has is a single state registration. For example, in the scenario

depicted in section 4.1, figure 5.0 would be a valid tag registration while figure 5.1 would be an invalid tag registration.



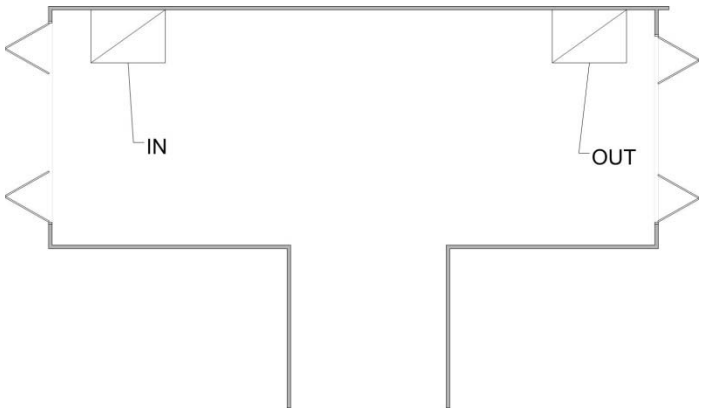


Figure 5.0 Valid Tag Registration Figure 5.1 Invalid Tag Registration with Single Controller

Also, since the unit is not functioning properly, specifically the Ethernet port, networking is much more difficult. The lack of Ethernet does not mean that networking is impossible, however as described in section 3.2.2 it is greatly limited by distance and by the number of physical COM ports on the computer. Currently, the current software configuration allows a tag to be registered, scanned, and its last scan time be returned. While ultimately the users should be able to issue commands as outlined in section 3.5, that area has not yet been fully developed.

5.3Future Work

This project is intentionally left open ended so that it may be continued in a number of ways.

5.3.1 Ethernet Adaptation

This continuation would require the purchase of a new MP9320 v2.8e or similar RFID controller device. The idea behind this new project would be to expand the connection class to the Ethernet port of the device and allow communications to be established over TCP/IP. This change would mean that the distance between the controller and the computer is no longer an issue. Moreover, this would lead up the multiple controllers project.

5.3.2 Multiple Controllers

This continuation assumes that either the controlling computer has multiple physical COM ports or the Ethernet adaptation project has already been accomplished. The multiple controllers project would allow the “invalid” operation in figure x.x (section 5.2). The tricky part of this future project would involve linking the controllers into a single java program and database. Ideally, the controllers would differentiate themselves with some signal which may be used for accurate reads and writes.

6. References

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7. Bishop, J. (2001). *Java Gently, 3rd ed.* Addison-Wesley Pub Co